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AUTHOR Dykman, Roscoe A.; And Others
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ABSTRACT

This paper covers selected findings from three studies that compared different diagnostic groups: boys with attention deficit disorder (ADD) with or without hyperactivity (HY) but normal reading ability; boys with reading disability (RD) but not HY; and boys with both RD and HY. Studies examined an adapted task to assess frontal and temporal lobe function, the effects of methylphenidate dosage, and information processing. It is suggested that HY subjects' inability to sustain attention, their lack of effort to think and remember, their inability to suppress extraneous and distracting stimuli, and their aggressive or impulsive behavior indicate frontal-lymbic dysfunction, with probable deficits in the "wiring" of inhibitory connections. Findings also suggested that the central nervous system dimension of sensitivity appeared to be a better predictor of drug efficacy than diagnostic labels. RD Ss appeared more impaired in auditory than visual vigilance, with HY Ss demonstrating the opposite. Five figures and a reference list are appended. (CL)

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Reading Disabled and ADD Children: Similarities and Differences

Roscoe A. Dykman

Peggy T. Ackerman

Phillip J. Holcomb

Department of Psychiatry and Behavioral Sciences

University of Arkansas for Medical Sciences

Little Rock, Arkansas 72205

EC 172747

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This paper will cover selected findings from three studies comparing different diagnostic groups of educationally troublesome boys: those having attention deficit disorder (ADD) with or without hyperactivity (HY) but normal reading ability, those with reading disability (RD) but not HY, and a mixed type who are both RD and HY. We have been one of the few groups to contrast two or more clinical groups with each other and normal achievers. Such a contrast is a necessity if one wishes to claim diagnostic specificity for findings inasmuch as normal achieving controls are superior to clinical groups on most measures obtained in the laboratory (Chapman & Chapman 1973).

All diagnoses were made by a veteran child guidance team using DSM-III guidelines. Additional research criteria were also employed. Thus, for a diagnosis of RD, a child had to have a combined average spelling and reading standard score on the Wide Range Achievement Test (WRAT) $\leq$90. Additionally, this mean score was 10 points or more below the child's Verbal or Performance WISC IQ in virtually all of the RD children. A child accepted into the HY study groups had to have a score of $\geq$15 on Conners' 10-item teacher rating scale. All subjects had WISC-R full scale IQs $\geq$90. There were 15-25 subjects per group in all studies reviewed, although some physiological analyses to be reported here were based on 10 subjects per group.

Study I

Some years ago, we (Dykman, Ackerman, Clements, & Peters 1971) proposed on the basis of our earlier work and that of others (Conners 1969; Conners, Rothschild, Eisenberg, Schwartz, & Robinson 1969; Conners, Eisenberg, & Barcai 1967; Sprague, Barnes, & Werry 1970) that attention deficits characterize learning disabled (LD) as well as HY children. Since this 1971 theoretical paper was entitled Specific Learning Disabilities: An Attentional Deficit Syndrome, it was not always quoted in the rapidly growing hyperactivity literature. But, like Douglas (1972), in her classic paper, Stop, Look and

Listen, we argued that attentional deficits rather than motoric restlessness should be of central research interest.

Even though the majority of LD children exhibit ADD symptoms, ADD cannot be said to be the sole or major cause of LD, for many ADD children, even HY ones, learn to read and spell at an age appropriate rate. This observation led us to believe that the major problem for LD children might be in the area of selective attention and for Hy children in the area of sustained attention. Moreover, we theorized the failure of HY children to sustain attention to be a lack of will to do so (Dykman & Ackerman 1976). Here we moved toward what William James termed intention. We further speculated that intention reflects frontal lobe action whereas selective attention, especially as used in reading, reflects temporal lobe involvement.

To test this theory, we modified a paradigm that Karl Pribram (1967) had used to assess frontal and temporal lobe functioning in monkeys (Dykman, Ackerman, & Oglesby 1979; Dykman, Ackerman, & McCray 1980). The child was asked to scan a visual field, discover which symbol is the target, learn to stay with the target for five trials, search for a new target, etc. He began with a visual field size of only two symbols, but the field size was increased by steps up to 12 symbols. Symbol presentation was under computer control, and any given symbol could occur in any one of 12 windows on a given trial.

There were two kinds of trials: search trials involved finding the to-be-rewarded stimulus and after-search reward trials involved staying with the correct object until it was no longer rewarded (5 trials). The child received one penny for each correct response. Total earnings were continually updated by a computer and displayed on a screen. Failures to choose the target consistently after discovery were not rewarded and were considered after-search lapses. In Pribram's monkeys, after-search lapses were increased by frontal lobe damage and search trials by temporal lobe damage.

Unfortunately for the specifics of the theory, the RD group did not differ from HY children in the number of search trials, after-search lapses, or reaction time (RT). Both clinical groups were however, inferior to Controls. When we later studied mixed HY-RD subjects, they, too, were inferior to Controls but not distinguishable from the "pure" clinical groups on Pribram performance measures. If we were to regard Pribram's paradigm as a valid test of selective and sustained attention or brain intactness, we could conclude that both HY and RD children have defective temporal and frontal lobe functioning. This is not to say that the children have lesions but rather could indicate subtle defects in neural connections and/or learned or acquired inattentiveness.

As we pointed out earlier (Dykman and Ackerman 1976), the kinds of behavioral deficiencies produced by injuries of the frontolimbic areas and associated cortex (Milner 1963) are very similar to those seen in ADD children - - hyperactivity, attraction to novelty, task impersistence, impulsivity, perseveration or inability to switch from one motion to another, dissociation of action and verbalization, and disregard for rules and consequences. Half of the HY children told us they had become tired and wanted to quit the Pribram task. The RD children, though tired, did not want to quit, yet they became inattentive as the difficulty of the task increased. The HY boys were more attracted to novelty than the RD children. In the early trials of one procedural condition, where the new symbol added to the visual field was always the one to be chosen for reward, HY children tended to choose the novel stimulus immediately whereas RD children did not (Dykman et al 1979).

In another sample of ADD, HY, and RD boys, the majority, when unmedicated, exhibited lapses of attention and extraneous responding (key-play) in the intertrial intervals of the Pribram task (Dykman et al 1980). As with the first sample, the HY boys were far more deviant in extraneous responding than

were the RD subjects. Methylphenidate dramatically decreased extraneous responding, particularly in HY subjects, and improved the performance of all clinical groups about equally (Dykman et al 1980). Interestingly, the drug had a greater effect in decreasing after-search errors than in decreasing search trials; i.e., it improved sustained more than selective attention (or memory).

Electrocortical data, obtained from one second before and one second after each display of stimuli, were Fourier transformed and subjected to a principal components analysis. Four components were extracted accounting for 87% of the variance. The first component had strong loadings between 16 and 20 Hz and weaker loadings between 8 and 10 Hz. The RD children had significantly lower scores on this component than the Controls, with the HY boys intermediate. However, the mixed HY-RD group, which were expected to be most impaired, were, in fact, least impaired of the clinical groups by this measure. We have no good explanation of this finding, but should say that this diagnostic group has been found aberrant in other studies. It may be that the combination HY-RD is compensating in some degree as regards arousal; e.g., RD children try harder (see below) while HY children are more easily aroused than pure RD children. These electrocortical results show that Controls exhibited superior task specific arousal (i.e., more beta and alpha activity) to the clinical groups. Previously we had found similar clinical groups to be deficient in physiological arousal, as indexed by heart rate and skin conductance response (Dykman et al 1971). Lowered task specific arousal has also been reported for animals with frontal lobe dysfunction (see review by Fuster 1980).

Turning to some psychometric data, the above clinical groups did not differ on WISC IQ variables, though all were inferior to Controls on the attention-sequential memory triad (Digit Span, Arithmetic, Coding). Unexpectedly, the normal reading HY subjects had higher scores than the RD

group on Flavel's 7-picture role taking task. HY children scored higher on this role-taking task, we believe, not because they are truly inclined to take the perspective of others but because they are more active processors of information, particularly of novelty. Non-hyperactive RD children tend to be passive, compliant, and rule-bound in our laboratory encounters with them. These personality traits could explain the higher scores of RD than HY boys on the Lie (or Defensiveness) Scale of the Eysenck Junior Personality Inventory. RD subjects are not overly defensive; they strive to be, and, in fact, are, good boys. HY and HY/RD children were rated higher on aggressiveness than the pure RD subjects (Conners' parent and teacher ratings). Using a structured interview (Davé 1963), we found that HY children received less home stimulation than either RD or Control subjects, perhaps because the HY boys were born to younger mothers (see Ackerman, Elardo, and Dykman 1979 for the above results).

Summary of Pribram Study

RD children did not differ from HY children as predicted on the Pribram task, but the study did yield evidence to suggest that dysfunctioning within certain regions of the frontal and temporal lobes may contribute to difficulties in learning and behavioral control: the assertiveness of HY and the passivity of RD subjects; the excessive key-play of the HY boys and their attraction to novelty; and the inferior search and hold performance of all clinical groups. Also, the sequential and phonetic difficulties of RD subjects implicate the posterior region of the left temporal lobe and associated cortical areas (Galaburda 1983).

Study II

The central focus of this study was again attentional problems. But a new variable related to attention was added, which we have termed sensitivity of the central nervous system (CNS). Russian investigators place this presumably

innate response bent along a weak-strong continuum, and Western biologically oriented psychologists such as Buchsbaum (1978), Eysenck (1981), Fowles (1980), Gray (1981), and Zuckerman (1983) believe this response propensity to be an important dimension of personality or cognitive style. Since RD and Hy children differ along a dimension of passivity and assertiveness, we hypothesized that these traits might have an underlying physiological basis in CNS sensitivity. According to the Russian literature (Nebylitsin 1972), a person with a strong nervous system responds to louder and louder tones or brighter and brighter lights with an orderly increase in physiological activity and an orderly decrease in reaction times (RTs). By contrast, the sensitive type shows an orderly increase up to a point and then responds less vigorously (i.e, exhibits transmarginal inhibition). Buchsbaum (1978) uses the terms augmentation and reduction to describe such gradients obtained from electrocortical evoked potentials. He reasoned, vis-a-vis the Russian experiments, that strong types augment and weak types reduce.

Following Nebylitsin (1972) we used RT slopes to tones of increasing intensity to characterize ADD and RD subjects as strong and weak (Ackerman, Holcomb, McCray, & Dykman 1982). To classify subjects as augmenters or reducers, we (Dykman, Holcomb, Ackerman, & McCray 1983) used the Buchsbaum measure, the N1-P2 component of the event-related potential (ERP).

We found, as Buchsbaum did, that children diagnosed as HY had more augmenting ERP slopes to tones ranging from soft to loud than did non-HY ADD or RD children (Dykman et al 1983) but there was considerable overlap (see Figure 1). But we found more HY subjects than those in other groups classified as weak or sensitive on the RT measure (Ackerman et al 1982). Non-HY ADD children typed strongest on the RT measure. There was little relation, however, between the ERP measure of augmentation and the RT measure of CNS strength. On theoretical grounds, the ERP measure should be a better measure

Insert Figure 1 About Here

of strength than RT, because it represents CNS activity in the first 200-300 msecs of information processing.

Heart rate (HR) generally decelerates markedly as an individual prepares to respond and then accelerates with the response. While ADD and RD groups exhibited less marked anticipatory HR responses than controls in the sensitivity paradigm, no systematic differences were found among the clinical groups (Ackerman, Holcomb, & Dykman 1984). But, with clinical diagnosis ignored, HR levels were consistently higher in ERP reducers than augmenters, and reducers switched more quickly from HR deceleration to acceleration (see Figure 2).

Insert Figure 2 About Here

Figure 3 shows the major relations between experimental variables in the pretreatment session of the sensitivity study and the subsequent clinically titrated methylphenidate doses. Our intent was to determine whether we could predict these carefully titrated dose levels from the pretreatment data. This analysis showed that many of the predictor variables were related at a low level, and that their conjoint effect was highly significant (multiple R=.892, $p<.001$). In Figure 3, type refers to the RT measure of weak-strong and slope to the ERP measure of augmentation-reduction. In general, we found a highly significant relation between ERP augmentation-reduction and drug-dose and drug-response (Dykman et al 1983). Relative to reducers, augmenters received smaller doses and had a superior drug response as judged by teacher ratings ($p<.01$).

Insert Figure 3 About Here

Turning to cognitive style variables obtained in the sensitivity study (Ackerman, Dykman, Holcomb, & McCray 1982; Ackerman, Dykman, & Oglesby 1983), the clinical groups did not differ on an Embedded Figures Test nor on the Matching Familiar Figures Test. HY children did perform better than RD children on the Leveling-Sharpening test of Santostefano (1970). The solely HY boys were more sensitive to the successive omission of details in an

elaborate drawing of a house and its surroundings - - evidence, in addition to the Travel task results, that HY children are more active processors of external change than non-HY RD or ADD children.

Summary of Typology Study

Our most significant findings had to do with the relation of drug titration and response to sensitivity variables as assessed from RT and ERP slopes to tones ranging from soft to very loud. Augmenters were blindly clinically titrated at significantly lower doses of methylphenidate than reducers and they had a much better medication response than reducers. This could mean that ADD reducers need medication other than methylphenidate, no medication at all, or that increasing doses of drug are really not beneficial. Since we have not done a dose-response study, we do not know whether small doses of methylphenidate help reducers as much as or more than large doses. Nearly all children, regardless of diagnostic label, improved in their classroom ratings with the clinically titrated drug dose, and all became more rapid in RT. But, the CNS dimension of sensitivity appears to be a better predictor of drug efficacy than the diagnostic label given a child.

Study III

The third study centered on information processing and consisted of two parts, one contrasting automatic and effortful memory processes and the other vigilance and memory scanning (Ackerman, Holcomb, Dykman, & Anhalt, Reference Note 1; Ackerman, Anhalt, Dykman, & Holcomb, Reference Notes 2 and 3; Holcomb, Ackerman, & Dykman, Reference Note 4). This study utilized four groups of children between the ages of 8 and 12 years: 24 soiely HY boys, 24 non-HY but RD boys, 21 boys who were ADD but not HY or RD, and 24 Controls. The first part of the study was based on the theory of automatic and effortful processing as outlined by Hasher and Zacks (1979). In order to become proficient in basic school skills, a child must develop highly automatized

habits requiring little thinking or effort. Hasher and Zacks point out that some automatic processes appear to be innate, but most are acquired through practice. We theorized that relative to both controls and normal reading ADD subjects, RD children would exhibit certain deficiencies in acquired automatic processing but that HY subjects would differ from Controls more in effortful than automatic processing because the former requires sustained attention (or intent to stay with a task).

Several purportedly innately automatic processes were incorporated into the study, e.g., sensitivity to frequency of occurrence of pictures of living creatures and sensitivity to recency of presentation of pictures of common objects. Tasks to measure acquired automatization included speed of picture naming, speed of writing "O's" and one's name, and simple addition and subtraction. Sensitivity to categorical and physical properties of words was also theorized to be automatic in school children with normal language development, and tasks included to assess this type automatization tapped sensitivity to acoustic and semantic similarities and to words high and low in imagery. Effortful processing was assessed with several memory tasks and by arithmetic problems involving simple borrowing and carrying.

All three groups of clinical children, like controls, gave evidence of intactness of innate processing. That is, they successfully demonstrated in response to probes their sensitivity to the varying number of times they had seen slides of living creatures - from zero to four times for each probe. They were 96% accurate in sorting previously viewed pictures of common objects from pictures from the same categories they had never seen before. And as the levels of processing literature predicts, all groups showed greater facility at learning and recalling highly imaginable words than words less imaginable, and all groups recalled semantically related words better than acoustically related words. As for acquired automatization of skills, the groups could not

be reliable discriminated on speed of naming or speed of writing. All three clinical groups were significantly poorer on all the arithmetic tasks than controls, even with IQ covaried out inasmuch as controls had significantly higher IQs than the clinical groups. But, the clinical groups did not differ from each other in computational efficiency.

Studies that have shown RDs impaired on naming speed (Denckla & Rudel 1976; Garnett & Fleischner 1983) have used a different task (the Boston Rapid Automatized Naming Task, or RAN) than the one we used and have not rigidly controlled for differences in IQ. But, we have not found differences in naming speed on previous studies using a task more like the RAN, i.e., the Santostefano Color Naming Task (Ackerman & Dykman 1982; Ackerman et al 1983). Perhaps naming speed is more sensitive with subjects younger than 8 years old, and when the task involves recurring alphanumeric stimuli as in the RAN.

The measures which proved most useful in discriminating the RD and ADD groups were from an effortful task, the acoustic-semantic memory task of Weingartner, Rapoport, Buchsbaum, et al (1980). In brief, the child listened to 20 sets of three words each, having been told to remember as many of the words as possible. For example, the child was asked, "Which word does not belong because of what it means: peas, spinach, house?" Then, "Which word does not belong because of how it sounds: man, can, clock?" Wrong answers were corrected by the examiner. After a distraction task, the child was asked to think back to the sets of words he had heard and to recall as many as possible. This free recall was followed by a cued recall in which the examiner read the child one of the two related words from each set and asked him to name, if he could, the other word of that pair.

We used stepwise discriminant analyses to contrast groups on effortful task variables, removing age and IQ first and second. In the contrast of RD and combined ADD children (both HY and non-HY), the discriminant function

yielded 77% correct classifications. This discrimination depended entirely on acoustic-semantic variables, i.e., the discrimination of words that did not rhyme or that were semantically unrelated, the recall of related words in the cued recall task, and the recall of related words in pairs (i.e., clusters) in free recall. Controls could be discriminated from RDs (96% correct) by semantic-acoustic measures, effortful arithmetic, and immediate memory for 12 visually presented first grade level words from three categories. And controls and combined ADDs could be correctly sorted (88% correct) by the effortful arithmetic task, immediate memory for the 12 visually presented words, and delayed memory for low imagery words.

While the contrasts of the clinical groups are of interest, the reality is that many children referred to our service fall between "the cracks" in these arbitrary research cut-offs. Thus, we combined our clinical and control groups in an attempt to arrive at some general conclusions applicable to all children in the age range of the study. In a stepwise regression to predict WRAT reading scores, we forced age and IQ, and then successively removed three variables from the acoustic-semantic task: cued recall of acoustic words, discrimination of unrelated words, and free recall clustering to achieve a multiple R of .59. Adding computational accuracy and delayed recall of low imagery words increased the multiple R to .83, explaining approximately two-thirds of the variance.

Summary of Effortful Processing Results

The finding of impaired phonological sensitivity in the RD group, not only relative to controls but also to children with ADD, corroborates and extends the findings of the Haskins Laboratory group in this country (Liberman, Liberman, Mattingly, & Shankweiler 1980) and Bradley and Bryant (1983) in England. The data from this experiment would also seem to say that ADD impedes automatization of arithmetic computational skills, in that all three clinical

groups were poorer than controls. And there is reason to believe that the automatization of arithmetic skills depends on frontal lobe functioning (Fuster 1980). Impaired phonological as well as semantic sensitivity coupled with some long-term memory dysfunction appear to cause reading problems in normally intelligent children. These are temporal lobe functions. Again in this experiment, RD children seemed to be relatively passive encoders and retrievers of more abstract verbal information, which would explain their poor memory for such material, even with cues.

In the second part of this experiment, the same clinical groups and controls as described above were studied on tasks purporting to tap vigilance and memory scanning. Both RTs and ERPs were obtained, but only partial results can be reported now. The three tasks used to assess vigilance were an auditory and two visual variants of the much studied Continuous Performance Task (CPT). In the auditory condition, the child was instructed to press a reaction time key as rapidly as possible only when he heard a high pitched tone and at no other time. This target tone occurred on 17% of the 250 trials; a non-target low pitched tone occurred on 67% of the trials and a non-target burst of white noise on 17% of the trials. The child had practice with the two tones but not the white noise, which was unexpected. In the visual conditions, the stimulus probabilities remained the same. The target was the 3-letter combination DTM; the high probability non-target stimulus was the combination RSC. For the first visual condition, the novel unexpected stimuli were combinations of three non-alphanumeric symbols (e.g., asterisks, dollar signs, or punctuation marks). For the second visual condition, the novel non-target stimuli were 42 different 3-letter words (e.g., dog, cat, car).

The error data were analyzed with the signal detection measures d' and B, the former being an index of sensitivity or vigilance, the latter an index of

risk taking. We also studied mean reaction time to target stimuli and intraindividual RT variability, thought by some to be a better index of attentiveness than mean RT.

In the auditory session, controls had higher d' scores than both RD and HY/ADD children. The groups did not differ in risk taking. Controls had faster RTs than each of the other groups, but only RD children were more variable in RT than controls.

In the two visual CPT sessions, controls were again more sensitive than HY children, particularly in the second session. RD children, however did not differ from controls on d'. In pairwise contrasts, RD children had significantly higher d' scores in the second visual session than the HY subjects. Controls were faster than the RD and ADD children in the visual sessions and had less variable RTs than the two ADD groups.

---------- Insert Figure 4 About Here ----------

The analyses of the P3 latencies to the visual CPT stimuli at Pz and Oz showed a significant group effect, hypothesized to reflect slower evaluation or encoding for the clinical groups than controls. The RD group had the slowest P3s on the target and non-target stimulus arrays, while the HY group were slowest on the unexpected stimuli, especially the words. Controls had larger amplitude P3s than the ADD and RD children to the expected target and non-target stimuli. To the unexpected novel stimuli, the RD group had considerably lower P3 and slow wave amplitudes to the words than symbols, but controls showed little difference between the two types of novel stimuli. The most intriguing major finding is that young RD subjects had much slower auditory P3 latencies than the young subjects in other clinical groups, but the latencies of the older RD subjects were more in line with the older children in other groups.

A variant of Sternberg's memory scanning task was used to try to shed further light on stages of information processing that might be impaired in

the clinical groups. Sternberg manipulated conditions to figure out how long it takes a subject to encode a probe stimulus, scan his memory to determine whether the probe is or is not in a previously presented memory set, make a decision, and execute a response. We used memory sets of 1, 3, and 5 consonant letters. The task was made more effortful in that the size and composition of the memory sets were varied randomly over trials. There were 20 "yes" and 20 "no" trials at each set size.

Overall, controls had higher accuracy scores than each of the clinical groups, but at set sizes 1 and 3, RD subjects were significantly more accurate than the ADD and HY subjects (Figure 5). Thus, RD children appear to perform better than ADD groups until a certain level of complexity is reached. Mean reaction times did not reliably separate the groups, but the two ADD groups had significantly more variable RTs than the controls, with the RD group intermediate.

Insert Figure 5 About Here

The event-related potentials of the RDs and controls to the Sternberg stimuli have been analyzed (Holcomb et al in press). The P3 amplitudes decreased as set size increased, yielding negative slopes, which is what other investigators have reported. At the occipital site, the RD children had significantly more negative slopes than controls, indicating that processing was more difficult for them at larger set sizes. The P3 latency slopes showed controls to have earlier zero intercepts (about 50 msec) than RD children, but this difference was reduced when IQ was partialled out. In this study, the controls' mean IQ was roughly one SD above the mean IQ of RD subjects, and IQ is a significant covariate of P3 latency.

Summary of Information Processing Tasks

The clinical groups had differing patterns of adverse scores in relation to controls but there were only a few significant differences between the clinical groups. The HY group showed a decrement in sensitivity during the

second visual CPT session, but the RD group did not and had significantly higher d' scores than HY subjects in this session. Also, the RD group was more accurate than the two ADD groups on the Sternberg with smaller set sizes. On the other hand, the RD group was least sensitive in the auditory version of the CPT, and, whereas two-thirds of controls had faster auditory than visual RTs, 83% of RD subjects had faster visual than auditory RTs (Chi Square=10.37, $p<.01$). Thus, RD subjects seem more impaired in auditory than visual vigilance. The opposite is true for HY subjects. But, Sternberg task results indicate RD children do falter on visual tasks when the information load is heavy - perhaps when they need to employ auditory recoding to keep the information in working memory. Auditory patterns, except for chords, generally require sequential processing, but less complex visual patterns can be processed globally, which seems to be the RDs children's preferred mode.

Conclusions

To return to our opening speculations, we are inclined to believe that HY children's inability to sustain attention, their lack of will (effort) to think and remember, their inability to suppress extraneous responses and distracting stimuli, their aggressive or impulsive behavior indicate frontal-limbic dysfunction, most likely subtle defects in the "wiring" of inhibitory connections (Dykman et al. 1979). When information becomes excessive or uninteresting, even normally attentive people exhibit attentional problems similar to those of HY children. The "defect" in these instances would, however, seem to be secondary, or elicited, rather than primary, and we believe that this is the case for most RD children. RD children exhibit attentional problems very similar to those of ADD children but less noticeable or intense until they are put into effortful information processing situations. When the phonologically handicapped RD child has to discriminate and remember closely related language sounds, his attentional capacity appears

overloaded. It is our belief that left hemisphere deficiencies, not necessarily subtle, in the posterior temporal lobe and adjacent regions of the angular gyrus are responsible for the language difficulties of RD children. Moreover, problems in temporal lobe processing (selective attention) can overload frontal lobe processing (sustained attention).

Methylphenidate, like dextroamphetamine, is a nonspecific stimulant that improves performance in a great variety of tasks. These psychostimulants achieve their effect, we believe, by increasing the sensitivity of nonspecific ascending and descending pathways, from and to the reticular system via the limbic system, thalamus, and frontal lobes. We have theorized elsewhere (Dykman et al 1971) that these drugs have their main effect on the forebrain inhibitory system, which when stimulated suppresses movement. There are other important ascending inhibitory systems that may also be involved (see review by Solonto 1984). Psychostimulants appear to augment selective attention by decreasing (1) the range of stimuli to which a person will respond and (2) competing response tendencies. These drugs also increase the willingness of a person to stay with a task, which is the hallmark of sustained attention. The fact that dextroamphetamine improves the performance of normals (Rapoport, Buchsbaum, Weingartner, et al 1980) does not necessarily mean that the effects of the psychostimulants are identical in normals and clinical cases nor in all clinical cases (see Pelham and Milich 1984).

Figures

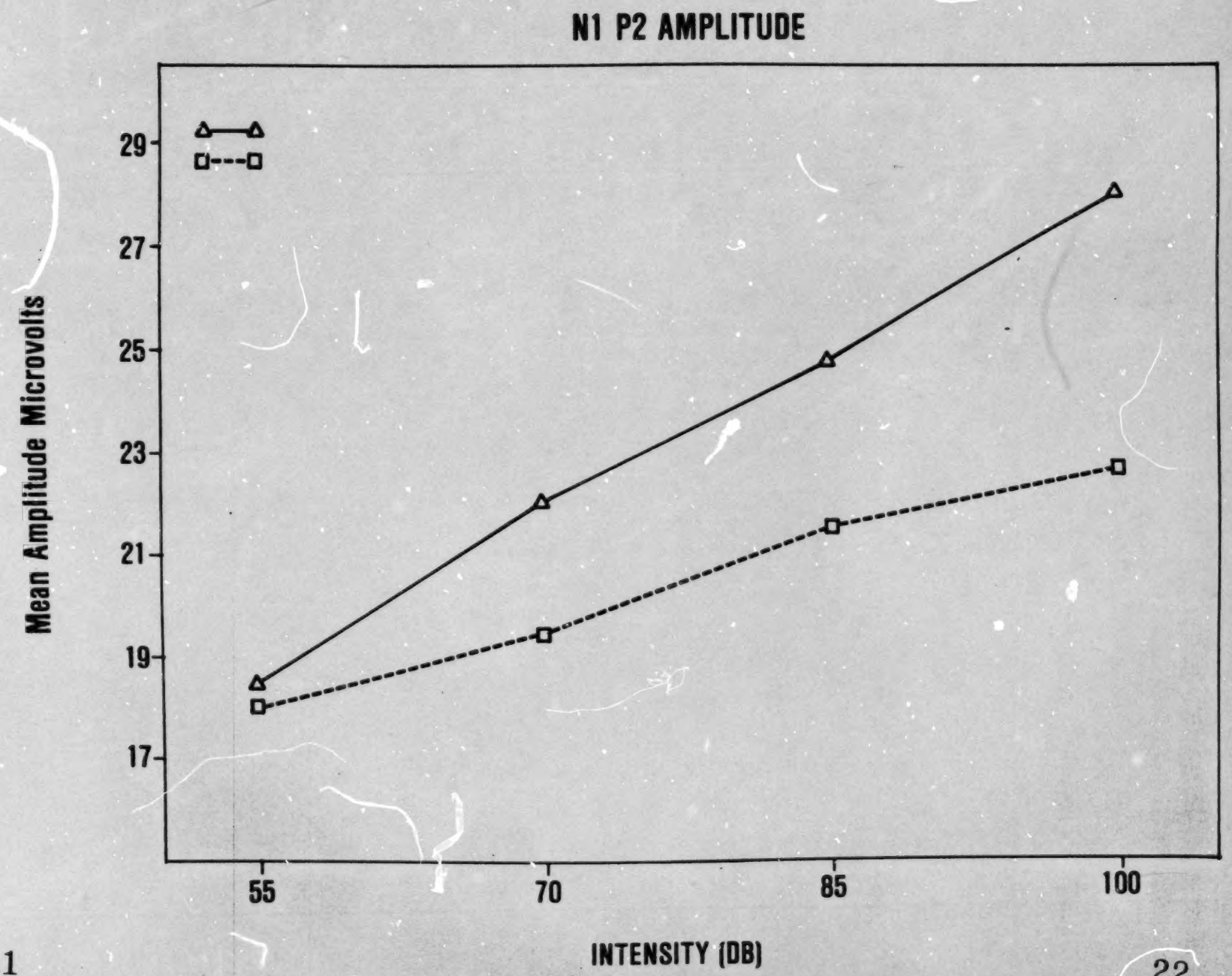
Figure 1. Mean N1-P2 gradients for two hyperactive (solid line) and two non-hyperactive (broken line) clinical groups.

Figure 2. Mean heart rate levels for 8 contiguous 1-sec. intervals from warning light past tone (imperative stimulus) offset.

Figure 3. Multiple regression analysis predicting titrated methylphenidate dosage levels from five sets of variables.

Figure 4. Continuous Performance Task (CPTs): Mean d' (sensitivity) scores in one auditory (A) and two visual (V) sessions for four groups.

Figure 5. Sternberg Task: Mean number of correct responses, yes and no, at memory set sizes 1, 3, and 5 letters for four groups.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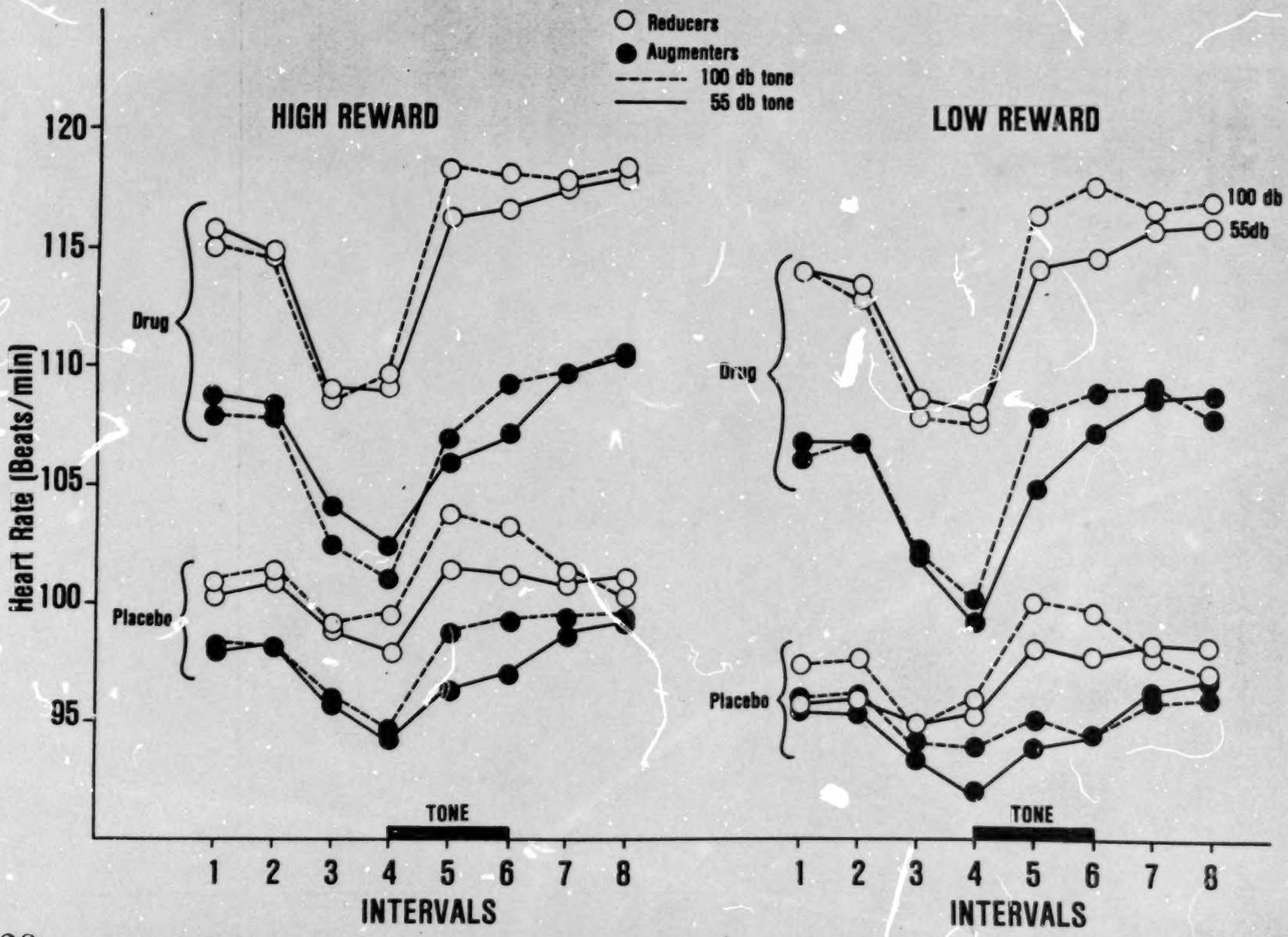
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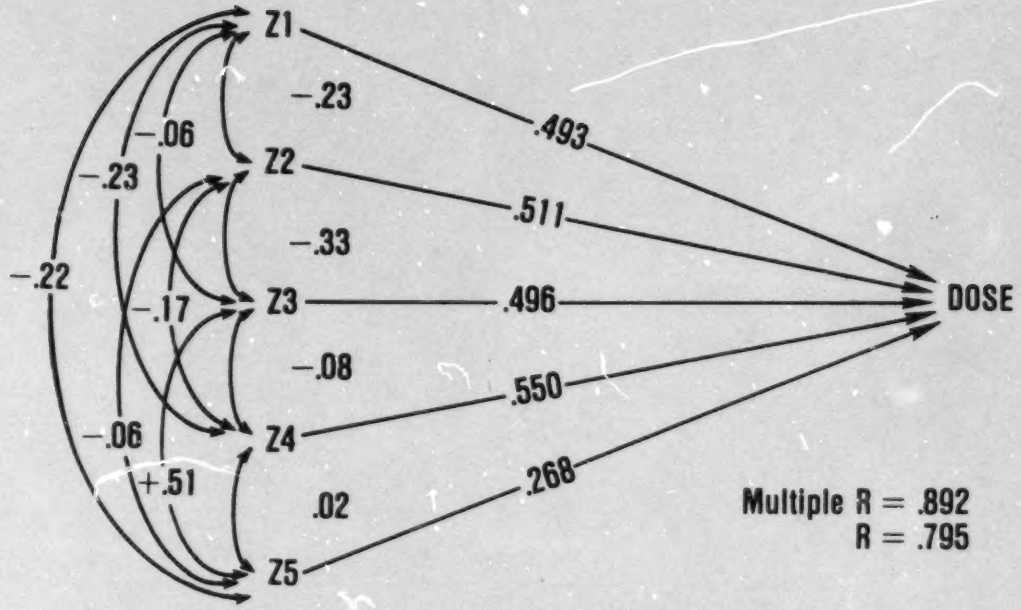
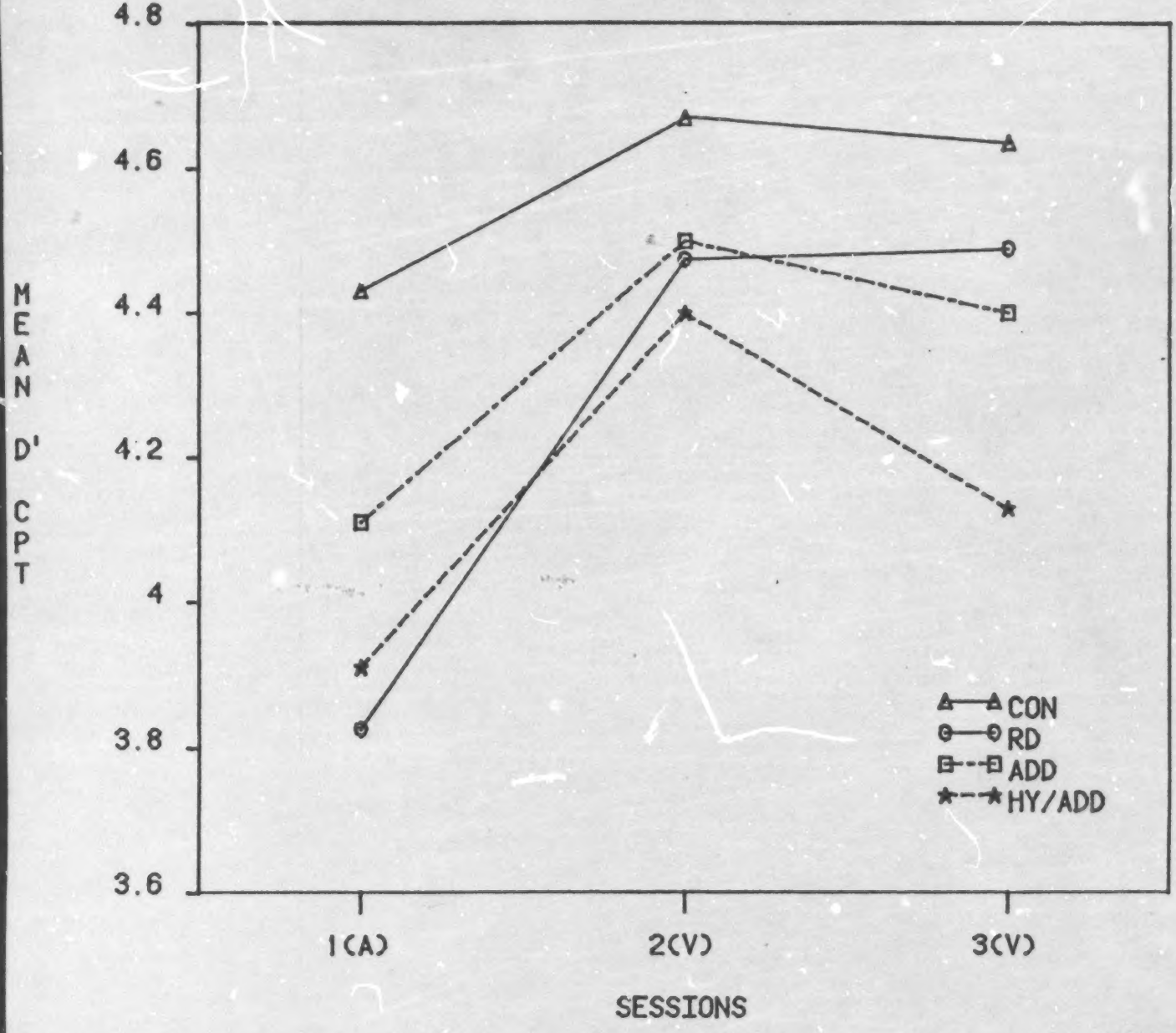
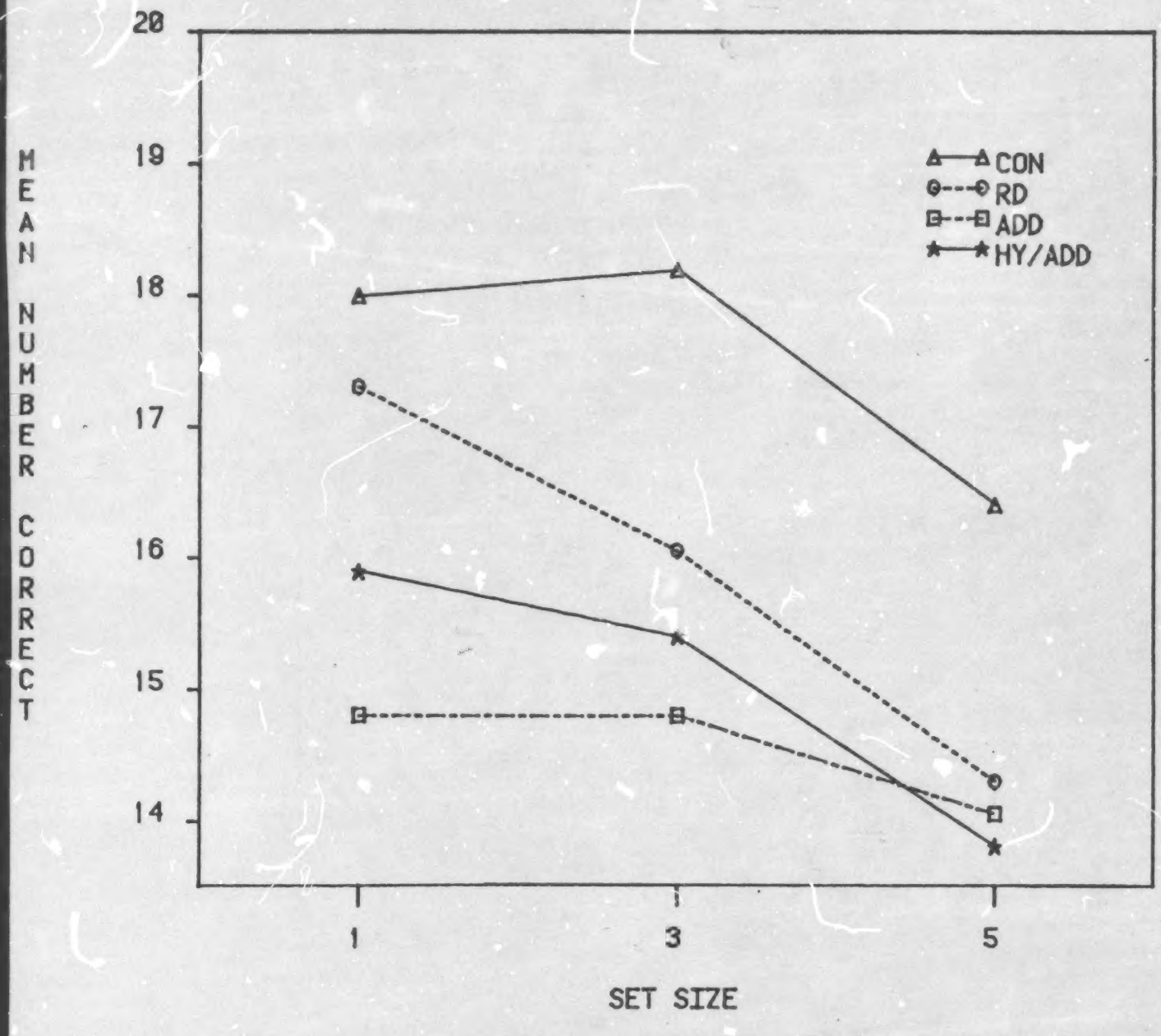


Multiple R = .892
R = .795

Z1 = Age + Weight
Z2 = ERP type − RT slope
Z3 = Press RT low reward — Press RT no reward
Z4 = 3 HR high reward + HR low reward − 2 HR no reward
Z5 = SC counts low reward − 2 SC counts high reward



MEAN NUMBER CORRECT


MEAN NUMBER CORRECT
20
19
18
17
16
15
14
1
3
5
SET SIZE
CON
RD
ADD
HY/ADD

Reference Notes

1. Ackerman, P.T., Holcomb, P.J., Dykman, R.A., and Anhalt, J.M. Information processing in educationally troublesome children. Submitted for publication.

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